

PATENT SPECIFICATION

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(54) A COLOR DISPLAY DEVICE

(71) We, BALL BROTHERS RESEARCH CORPORATION, a Corporation organised and existing under the laws of the State of Colorado, United States of America, of, Boulder Industrial Park, Boulder, Colorado, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention generally relates to a color display system and to a new use for visual display screens which produce different colors in respectively corresponding different areas of the display screen.

Monochromatic black and white alphanumeric display devices and systems are today a common sight. Perhaps the general public is most aware of such displays and their use in public areas such as airports, train stations and the like where transportation identification, routing, status, gate location, etc., information displayed in monochromatic alphanumeric displays. Usually, rather well-defined line and columnar formats are utilized or can be utilized for this data such that a particular category of data is always programmed to appear at a respectively corresponding relative position in the overall display.

While such monochromatic displays are a great help and benefit in many circumstances, it has long been recognized that multicolor visual displays can be much more effective than monochromatic displays in achieving the desired communication interface with the human mind. Thus, if a particularly important pre-determined component of the total display is displayed in some color unique (i.e. orange-red) from the rest of the display, most humans will automatically have their attention drawn to that component of the display which appears in the special dif-

ferentiating color.

Although such a multicolor display has thus been a desirable goal in the past, it has for various reasons such as those to be discussed below, failed to come into practical being.

In the first place, conventional color television systems require expensive and complex display tubes and driving circuitry therefor. For instance, in a conventional color television picture tube, the phosphors which emit the three primary colors are deposited in a vast array of very accurately positioned minute dots or stripes whereby selective electron bombardment of phosphors corresponding to the three primary colors at each small picture display element produces a mixture of such primary colors, insofar as the human eye can detect, which appears then as a minute spot of light having and desired color in the visual spectrum. In addition to manufacturing difficulties and expenses involved in accurately depositing the minute elemental areas of the primary color phosphors, there are many further expensive complications involved in both the tube structure and the driving circuitry therefore to insure that the electron beams (there is usually more than one electron gun in a conventional color tube) are properly converged and deflected in registry with a mask or with the elemental phosphor areas *per se*. All of the present color tubes, including the shadow mask type and the Trinitron (Registered Trade Mark), have severe resolution limits plus the requirement of complex registration and convergence circuits. They are also relatively inefficient requiring high deflection power and high voltage sources for the light output achieved.

In addition to the economic factors caused by complexity and expense as noted above, there is still another practical

reason why the usual sizes of conventional color television tubes are not suitable for use in most alphanumeric display systems. Typically, an alphanumeric display system must be capable of displaying the basic standard "page" of alphanumeric text which is an array of 80 alphanumeric characters across, horizontally, by 24 alphanumeric characters vertically so that there are approximately 1,920 positions in the total display at which any desired alphanumeric character may be positioned. While it has been possible to achieve the required high density resolution with conventional black and white or monochromatic television picture tube displays, it has not been possible to attain sufficient resolutions with conventional color picture tube systems, especially of the smaller tube sizes, which will permit this required density of alphanumeric characters in the total display. Typically, for the same size of overall display, a monochromatic or conventional black and white picture tube screen is capable of achieving approximately 100% high resolution than the same size of conventional color picture tube. Still further, the conventional color picture tubes, even if their use is attempted in alphanumeric display systems, have inherent characteristics which are rather undesirable for such systems. For instance, the phosphors used in a conventional color picture tube are designed to provide primary color which, when mixed, will produce the desired composite colors response from the human eye. However, the output of the red phosphor or of the blue phosphor *per se*, in the conventional color picture tube is positioned in an undesirable area of the visual response spectrum.

According to the present invention there is provided a position programmable color display system for providing a composite multicolor visual display having a plurality of non-overlapping areas wherein the color of portions of the total composite display appearing are a predetermined color and wherein the color of any portion of the total composite display is controlled by controlling the relative position of said display portion, said system comprising: a composite display cathode ray tube screen having a plurality of discrete areas which produce visible light output when inherently activated to present a composite visual display having separate non-overlapping portions; a single electron gun activation means; control means operatively disposed to selectively activate predetermined said areas of said display screen whereby said portions of the composite visual display are controlled to appear at respectively corresponding predetermined different positions on said display

screen; said areas of said display screen means comprising; a first area having thereon phosphors which emit visible light of a first predetermined color when activated by said electron gun and said first area being dimensioned in surface area to encompass at least one complex image of said total composite display, and a second area positioned distinctly from said first area and having thereon phosphors which emit visible light of a second predetermined color, different from said first color when activated by said electron gun and said second area being dimensioned in surface area to encompass at least one complex image of said total composite display, such that no two contiguous, non-overlapping areas are of the same color.

Further according to the present invention there is provided a method of generating a composite multicolor visual display with the system just described, wherein said cathode ray tube has a light output face which produces different colors at respectively corresponding different areas of said light output face, said method including the steps of: activating a first area on said light output face having thereon phosphors emitting visible light of a first predetermined color when activated by said electron gun wherein said first area is dimensioned large enough in surface area to encompass at least one complex image of said total composite visual display; activating a second area positioned distinctly from said first area and having thereon phosphors emitting visible light of a second predetermined color, different from said first color when activated by said electron gun wherein said second area is dimensioned large enough in surface area to encompass at least one complex image of said total composite visual display; controlling the activation of said cathode ray tube whereby the display color of predetermined portions of the total composite display are determined by the relative position of the predetermined portion within said composite visual display.

The term "complex image" is used in this specification to mean at least one item of display data which is made up of two or more elemental portions of the display screen at least in the verticle direction.

The term "position programmed" means that a color of a predetermined component of the total display is determined by the relative position of that display component within the overall display.

Now, however, it has been discovered that the desired high resolution, high efficiency multicolor visual display maybe quite easily and simply attained by providing a rather simple and straightforward al-

teration to the conventional monochromatic or black and white cathode ray tube systems. The altered cathode ray tube (CRT) structure is almost as cheap to manufacture as conventional black and white or monochromatic tube structures and, when the altered CRT is substituted for a conventional CRT in a conventional black and white display system the display is thus automatically converted by the altered CRT to a multicolor display wherein the color of a predetermined component of the total display is determined by the relative position of the display component in the overall display.

The unwanted or undesirable characteristics of the page format and columnar display of alphanumeric data and of the displays used in electronic games lends itself to predetermined phosphor areas which can be programmed for use by predetermined components of the display to achieve color. A similar end result might be attempted by using color filter overlays on the picture tube face of a conventional black and white display. This attempt would reduce light output, limit color range available and suffer from parallax where letters, numerals or other data were only a fraction of the face plate thickness. A predetermined phosphor format restricts the keyboard operator or computer programmer to key position of display components, to color and to have only certain predetermined colors available for programmed use. However, the advantages outweigh these limitations and include high resolution, high light output, lack of color convergence adjustments, the ability to use standard black and white drive circuits to produce color and high efficiency, lower high voltage circuits, etc., to mention only a few. Thus, this invention permits one to convert present black and white display systems into color display systems.

Different colored phosphors are conventionally coated on the face plate of the CRT in discrete areas which are dimensioned large enough in surface area to substantially encompass at least one separate complex image of the overall display. Since the phosphors in any given discrete area are of the same color and uniformly applied by conventional coating techniques used for white light emitting phosphors, the resolution capacity of the overall screen is substantially the same high resolution as that attainable with conventional black and white displays. Other than for the fact that one or more discrete areas of the tube face are coated with phosphors which emit colors different from other areas of the tube face, the modified CRT is a conventional single electron gun picture tube which may be driven by conventional in-

expensive, uncomplicated black and white display driving circuitry.

When this altered CRT is used in a conventional black and white alphanumeric information display system, a multicolor display system is produced in spite of the fact that cheaper, less complex black and white driving circuitry is utilized. As one example, an airline schedule display may have one area of the display normally used for denoting the airline and flight number in conventional white light emitting phosphors while other areas of the tube normally used for displaying the current status, scheduled departure time, etc., would comprise colored light emitting phosphors. Thus, in this embodiment, vertical columns in the overall alphanumeric display would take on predetermined corresponding colors.

There may also be provided differently colored light emitting phosphors in horizontal strips having vertical dimensions at least equal to the vertical dimensions of the individual data or alphanumeric characters so that individual lines of the alphanumeric display take on different color characteristics as determined by the relative position of the displayed line within the overall display.

The different discrete areas are formed by selective masking of the areas where phosphor coating is not desired during otherwise conventional coating of the unmasked area with phosphors having any desired color of light emission. By repeating this process for each area, the desired composite tube face plate having areas of differently colored light emitting phosphors is formed.

Since the different color phosphor light outputs are not intended to be mixed as in conventional color tubes, it is possible to use phosphors which produce a greater intensity of color than in such conventional tubes. Further, there is no problem with phosphor beam registration as in conventional color tubes since there is no intermingled array of closely positioned different colored phosphors, etc.

It is recognized that others in the prior art have distributed differently colored phosphors in various patterns over the faces of CRT tubes in the past to define the accurately positioned arrays of minute elemental areas of differently colored phosphors in conventional color picture tubes. As should be appreciated, such prior art conventional color picture tube structures are quite different from the invention described herein in that they in no way teach or suggest the provision of separate discrete areas for producing visible light in separate predetermined different colors which areas are dimensioned large enough

in surface area to substantially encompass at least one separate complex image of the overall display, for example, a complete alphanumeric character. In fact, in any conventional colorpicture tube structure, a complete alphanumeric character or other component of the overall display would undoubtedly encompass many minute phosphor areas emitting all three of the primary colors which is, of course, quite contrary to the structure of this invention.

It is also known that some of the early attempts to produce color television involved cathode ray tube structures wherein the complete overall display image was produced a plurality of times on different areas of the display screen with each area producing the entire image in a different one of the primary colors. The multiple images were then optically combined in an attempt to produce a naturally colored composite image for viewing purposes. Here again, this prior art structure in no way teaches or suggests dividing up the complete display so that separate complex images of a single image are caused to appear in different colors at respectively corresponding different positions on the display screen within a single image area.

Still further, it is known that plural beam cathode ray tubes include a sectioned overall display screen wherein different components of the overall display are presented in respectively corresponding sections. In effect, such systems are really just a composite of several separate CRT structures with each one of the separate structures taking on a respectively corresponding portion of the overall display. Certainly, there is no teaching or suggestion here that such different segments of the overall display should be capable of producing respectively different corresponding display colors.

The fact that no one in the art has heretofore proposed the invention as described and claimed herein makes it apparent that the rather simple yet profoundly significant features of this invention have not been apparent to those in the art heretofore. As will become even more apparent from the following detailed disclosure, the invention described and claimed herein achieves the long desired multicolored display using a slightly modified but otherwise conventional black and white cathode ray tube in conjunction with conventional black and white driving circuitry therefor. Thus, with this invention, the desired multicolor display is achieved at roughly the same expense and level of complexity as was heretofore necessary for monochromatic or black and white displays.

The objects and advantages of this invention will be more completely ap-

preciated from the following detailed description taken in conjunction with the accompanying drawings in which:

FIGURE 1 is a pictorial view of a first exemplary embodiment of this invention;

FIGURE 2 is a pictorial view of a second exemplary embodiment of this invention; and

FIGURE 3 is a block diagram of a position programmable color alphanumeric display system which constitutes still another exemplary embodiment of this invention.

Referring to FIGURE 1, a cathode ray tube is generally indicated at 20. In general terms, it comprises a structure which is generally similar to the usual monochromatic black and white CRT which involves a single electron gun 22 within a tube structure 24 and which permits a focused beam of electrons from gun 22 to be deflected through various angles onto any desired portion of a phosphor coated screen 26. As will be appreciated by those in the art, the phosphors coated on the inside of the screen 26 produce visible light output when activated by electrons impinging thereon from the electron gun 22 which may be considered as a display screen activating means in the CRT structure context. The glass envelope 24 of tube 20 can be assembled from any of the accepted television picture tube envelope sizes.

As indicated in FIGURE 1, the otherwise conventional CRT 20 is modified in that a predetermined multicolor phosphor format is provided on the screen 26 to complement a visual data display thereon so that discrete areas or components of the visual display are provided with predetermined colors corresponding to the phosphor coating on that particular area of the screen 26. For illustrative purposes, the exemplary embodiment shown in FIGURE 1 has a first area 28 which is provided with a coating of white light emitting phosphors for producing visible light of a "white" color when activated. The white phosphor coated area 28 is dimensioned large enough in surface area to substantially encompass at least one separate component (i.e. at least one complex image or character) of the overall display. As shown, for example, in FIGURE 1, the white phosphor coated area 28 is large enough to encompass the vertical column of alphanumeric characters which, on any given line of the display, describe the airline and flight number, etc.

The exemplary embodiment shown in FIGURE 1 also includes a second area 30 which is positioned distinctly from the first area 28 and which includes means such as a green light emitting phosphor coating for producing visible light having a color

which is different from the light produced by the phosphors in area 28. Again area 30 is dimensioned large enough in surface area to substantially encompass at least one separate component of the overall display. For example, as shown in FIGURE 1, the area 30 comprises a vertical column or strip which substantially encompasses a column of alphanumeric characters which, on any given line, describes the status of a respectively corresponding airline flight.

As also shown in FIGURE 1, this particular embodiment includes still a third area 32 positioned distinctly from both the first and second areas 28, 30 and including a red phosphor coating for producing visible light having a color which is different from both the first and second colors. As before, the area 32 is also dimensioned large enough to substantially encompass at least one separate component of the overall display. For example, as shown in FIGURE 1, area 32 is a vertical strip substantially encompassing a vertical column of alphanumeric characters which, on any given line, describes yet another status parameter for a respectively corresponding airline flight.

As should now be apparent, the embodiment shown in FIGURE 1 provides a color striped format with each different color producing area being vertically oriented when compared to the horizontally displayed data. This embodiment is particularly adaptable to airline flight information display systems, screens, or any other type of digital data which is read out and displayed in vertical columnar formats. Thus, with this invention, the data presented in two or more vertical columns of such a format may be significantly distinguished by the different colors that are utilized for the corresponding vertical screen areas encompassing these columns of alphanumeric data.

Of course, it should be apparent that such data might comprise all alphabetic information or all numeric information but that the term alphanumeric as used throughout this application refers generically to alphabetic characters or numerical characters or to any combination thereof.

The CRT structure as shown in the exemplary embodiment, for example, of FIGURE 1 utilizes a single electron gun structure for focusing the electron beam on light emitting phosphors deposited on the glass face plate as in conventional monochromatic black and white television picture tubes. While it would be possible to utilize multi-electron gun structures, this would increase the cost of the tube and the cost and complexity of driving circuits required therefor, but may be advantageous in some

applications.

Since the colored light emitting phosphors utilized for the different areas of the display screen are not utilized in a color mixing scheme for reproducing a variable color spectrum, the fixed color producing phosphors utilized in these areas can be optimized to enhance the viewing ease, attention getting characteristics or visual acuity parameters for this particular portion of the display. In this manner, one of the problems mentioned above with conventional color television picture tube phosphors is overcome. Of course, it should now be apparent that the multicolor display of this invention does not require any electronic coding for convergence, color mixing, etc. Rather, it is only necessary to register the scanning electron beam with the desired phosphor area. In this manner, the color display device is position programmable since it provides a multicolor visual display wherein the color of a predetermined component of the total display is determined by the relative position of that display component within the overall display.

FIGURE 2 depicts an embodiment of this invention quite similar to that of FIGURE 1 except for the relative orientation and size of the differently colored phosphor screen areas. Here, the different color producing areas of the display screen are presented in a horizontal striped format in line with a horizontally oriented line of alphanumeric characters to be displayed where the individual color producing stripes are approximately equal in height to the vertical size of the data character being displayed. For instance, as shown in FIGURE 2, 16 horizontal alphanumeric display lines are shown having identifying numerals 1-16 as indicated in FIGURE 2. The color produced by the phosphor stripes is shown by various types of cross-hatching which is explained in a key symbol chart in FIGURE 2.

With the embodiment shown in FIGURE 2, it is possible to position share the face plate of the display screen between various combinations of color producing phosphors thus creating individual lines of different colors or, by scanning in a skipped line mode, single colors on adjacent lines may be scanned to produce a full page data display or a single color. As an example, the illustrative example shown in FIGURE 2 could be scanned to display an all black and white page of alphanumeric data by scanning only lines 1, 2, 3, 6, 7, 8, etc., and by skipping lines 4, 5, 9, 10, etc. Conversely, the scan could be controlled to skip all of the white phosphor stripes and to scan only lines 4, 9, 14, etc., whereupon the al-

phanumeric information displayed would appear in a green color. Similarly, by scanning only lines 5, 10, 15, etc., one could display a totally red colored readout of alphanumeric data. As should now be apparent, there are almost unlimited numbers of combinations for phosphor formats that could be used to complement the human reaction to color while displaying alphanumeric data. There may be unlimited geometric discrete phosphor area designs and color combinations which would be useful in cathode ray display applications, for instance, in electronic game displays. It should also now be apparent that the embodiments of FIGURES 1 and 2 could be combined in various combinations and permutations.

Referring now to FIGURE 3, an alphanumeric display system which may be position programmed to produce multicolor alphanumeric displays is depicted in an exemplary embodiment. Here, the position programmed color display tube 40 comprises either of the exemplary embodiments of FIGURE 1 or 2 or variations thereof.

The conventional single gun (i.e., black and white) alphanumeric display driver 42 would comprise the conventional video analog circuits necessary for scanning the electron beam over the display surface, modulating it as appropriate to produce the desired alphanumeric display. Conventional circuitry for performing these functions is available from Miratel Division of Ball Brothers Research Corporation in St. Paul, Minnesota, U.S.A. For instance, the Model T.V. 12 series would include such driving circuitry. Presently, the Model T.V. 12 is supplied with a conventional black and white television CRT. The modified CRT as described above may be directly substituted for this conventional black and white CRT.

The driving circuitry 42 obtains its video signal input from conventional character generator circuitry 44 as also shown in FIGURE 3. This conventional character generator might, for instance, comprise a Hazeltine Model 2000 or Model 1000 character generator which may be driven by digital electrical signals in the ASCII code as will be appreciated by those in the art. The ASCII code representing a sequence of alphanumeric characters to be displayed and the predetermined relative positions in which such alphanumeric characters are to be displayed may be produced either by conventional keyboard data terminal circuits 46 which are manually activated or by a conventionally programmed commercially available general purpose computer 48. For instance, any conventional computer which can be programmed to produce digital electrical sig-

nals in the ASCII code may be conventionally programmed, as in the past, for generating such digital electrical signals for input to the character generator 44 thus defining the sequence of alphanumeric characters to be displayed and the predetermined relative positions in which such alphanumeric characters are to be displayed.

When the system of FIGURE 3 is utilized with an exemplary embodiment such as that shown in FIGURE 2, the conventional keyboard terminal 46 could be modified if desired so as to produce enabling or disabling signals which cause the character generator and driver circuitry to automatically skip certain predetermined display lines (corresponding, for instance, to some attention getting color) unless such a control is overridden with an appropriate manual actuation whereupon the data would be displayed in a line that was normally skipped and thus in a color that is different than that ordinarily produced by the display. The computer 48 could also be programmed to normally skip such lines, etc., if desired.

From the above description, those in the art should recognize that a position programmable color display device and system have been described for providing a multicolor visual display wherein the color of a predetermined component of the total display is determined by the relative position of the display component within the overall display. While only a few specific exemplary embodiments have been described in detail and these particular ones in the context of a CRT display screen, those in the art will appreciate that many variations and modifications of these specific exemplary embodiments are possible without in any way departing from the spirit or scope of this invention. Accordingly, all such modifications and variations are intended to be included within the scope of this invention as defined by the hereinafter appended claims.

WHAT WE CLAIM IS:

1. A position programmable color display system for providing a composite multicolor visual display having a plurality of non-overlapping areas wherein the color of portions of the total composite display appearing are a predetermined color and wherein the color of any portion of the total composite display is controlled by moving the relative position of said display portion from one part of the overall display to another part of the display, said system comprising: a composite display cathode ray tube screen having a plurality of discrete areas which produce visible light output when inherently activated to present a direct composite visual display

having separate non-overlapping portions; a single electron gun activation means; control means operatively disposed to selectively activate predetermined said areas of said display screen whereby said portions of the composite visual display are controlled to appear at respectively corresponding predetermined different positions on said display screen; said areas of said display screen means comprising: a first area having thereon phosphors which emit visible light of a first predetermined color when activated by said electron gun and said first area being dimensioned in surface area to encompass at least one complex image of said total composite display, and a second area positioned distinctly from said first area and having thereon phosphors which emit visible light of a second predetermined color, different from said first color when activated by said electron gun and said second area being dimensioned in surface area to encompass at least one complex image of said total composite display, such that no two contiguous, non-overlapping areas are of the same color.

2. A display system as in claim 1, wherein said composite display complex images comprise alphanumeric characters and said first and second areas comprise horizontally oriented strips having a height at least as great as the expected vertical dimensions of the alphanumeric characters used in said composite display whereby a horizontal line of such alphanumeric characters may be caused to exhibit either said first or second color depending upon whether it is caused to appear on said first or second areas respectively.

3. A display system as in claim 2, wherein additional horizontally oriented strips substantially the same as said first and second areas are disposed at vertical intervals on said display screen.

4. A display system as in claim 1, wherein said composite display complex images comprise alphanumeric characters and said first and second areas comprise vertically oriented strips having a width at least as great as the expected width of the alphanumeric characters used in said composite display whereby a vertical column of such alphanumeric characters may be caused to exhibit either said first or said second color depending upon whether it is caused to appear on said first or second areas respectively.

5. A display system as in claim 1, 2, 3, or 4, wherein said display screen means further comprises a third area positioned distinctly from said first and second areas and having thereon phosphors which emit visible light of a third predetermined color different from said first and second colors

when activated by said electron gun and said third area being dimensioned large enough in surface area to substantially encompass at least one of the said separate non-overlapping portions of the overall composite display.

6. A display system as in any one of the preceding claims, wherein said control means includes signal generation means for producing electrical signals representing a sequence of said complex images to be displayed and representing the predetermined relative positions in which such complex images are to be displayed, and activation means connected to receive said electrical signals and operatively disposed to respond thereto by selectively activating the predetermined areas of said display screen to display said sequence of complex images at said predetermined relative positions.

7. A display system as in claim 6, wherein said signal generation means comprises: manually activated keyboard digital data terminal means providing digital electrical signals representing said sequence of complex images and representing said predetermined relative positions, image generator means connected to receive said digital electrical signals and to produce corresponding analog electrical signals in response thereto, and driver means connected to receive said analog signals and to drive said activation means in response thereto.

8. A display system as in claim 6, wherein said signal generation means comprises: programmed computer means for providing digital electrical signals representing said sequence of complex images and representing said predetermined relative positions, image generator means connected to receive said digital electrical signals and to produce corresponding analog electrical signals in response thereto, and driver means connected to receive said analog signals and to drive said activation means in response thereto.

9. A method of generating a composite multicolor visual display with the system of any one of the preceding claims, wherein said cathode ray tube has a light output face which produces different colors at respectively corresponding different areas of said light output face, said method including the steps of: activating a first area on said light output face having thereon phosphors emitting visible light of a first predetermined color when activated by said electron gun wherein said first area is dimensioned large enough in surface area to encompass at least one complex image of said total composite visual display; activating a second area positioned distinctly from said first area and having thereon phosphors emitting visible light of

a second predetermined color, different from said first color when activated by said electron gun wherein said second area is dimensioned large enough in surface area to encompass at least one complex image of said total composite visual display; controlling the activation of said cathode ray tube whereby the display color of predetermined portions of the total composite display are determined by the relative position of the predetermined portion within said composite visual display.

10. A position programmable color cathode ray tube display system constructed and adapted to operate substantially as herein described with reference to the accompanying drawings.

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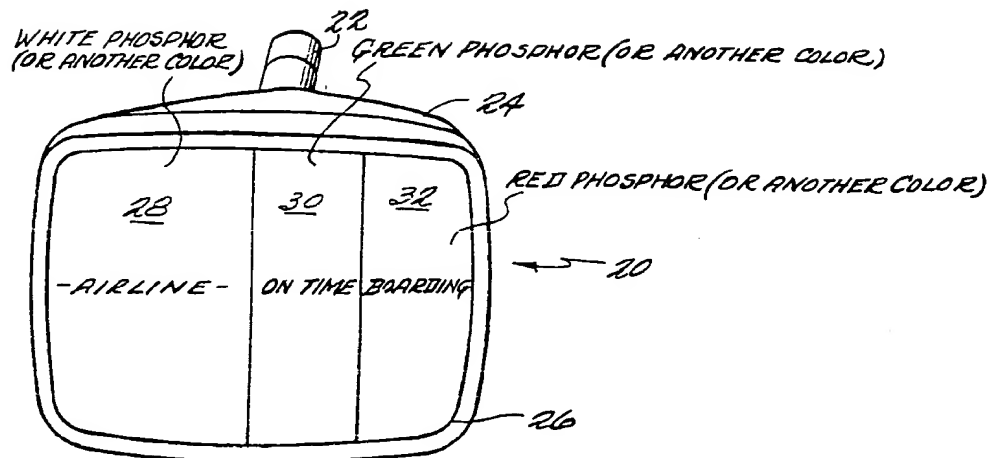





Fig. 1

-  WHITE PHOSPHOR STRIPE
-  GREEN PHOSPHOR STRIPE (OR ANOTHER COLOR)
-  RED PHOSPHOR STRIPE (OR ANOTHER COLOR)

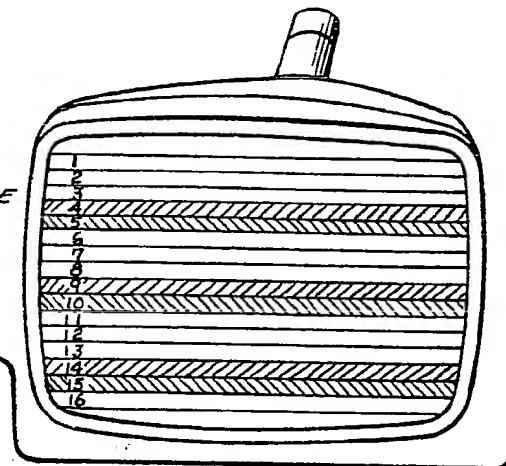


Fig. 2

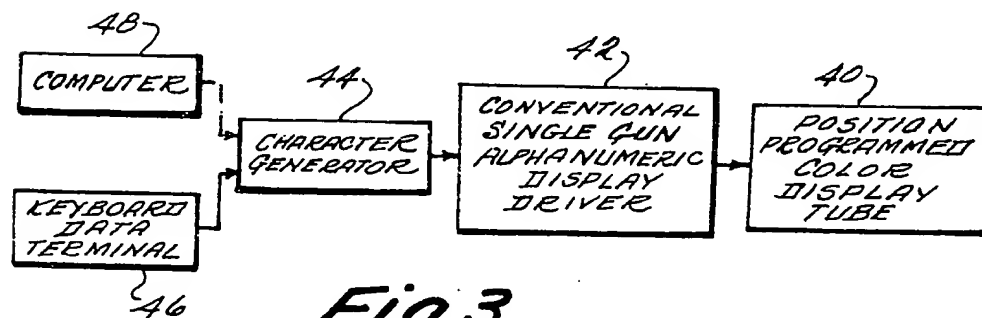


Fig. 3

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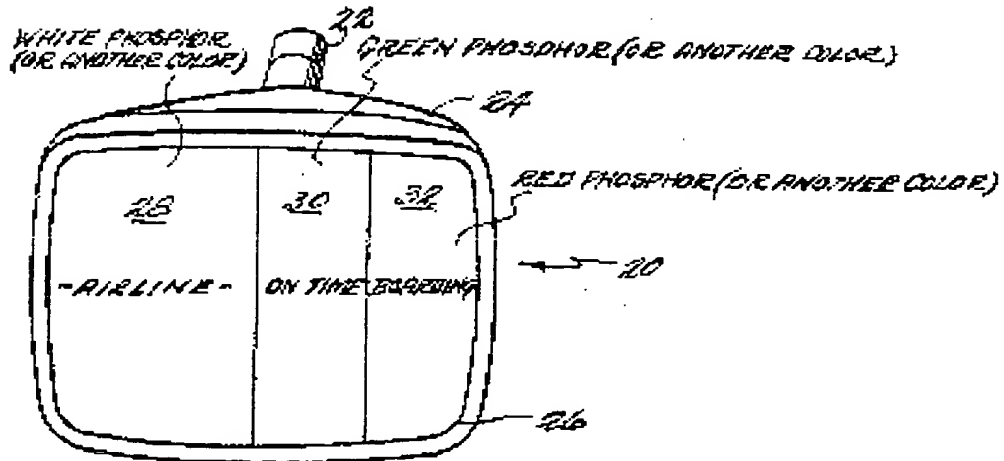


Fig. 1

- WHITE PHOSPHOR STRIPE
- GREEN PHOSPHOR STRIPE (OR ANOTHER COLOR)
- RED PHOSPHOR STRIPE (OR ANOTHER COLOR)

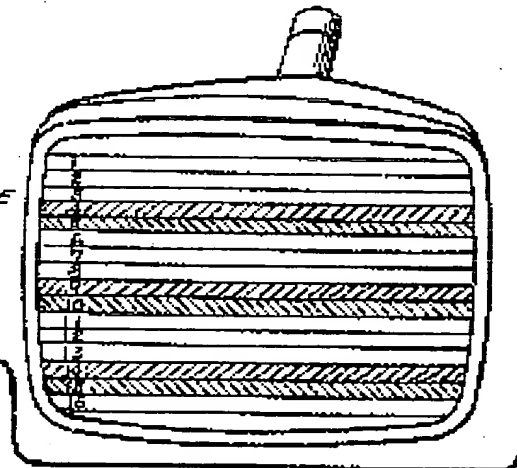


Fig. 2

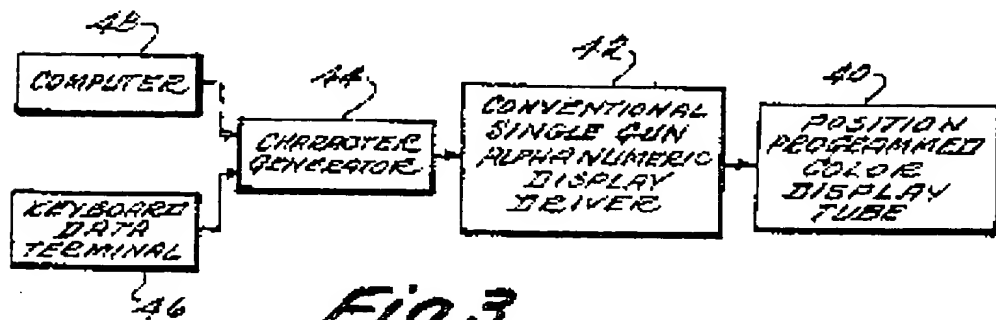


Fig. 3

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